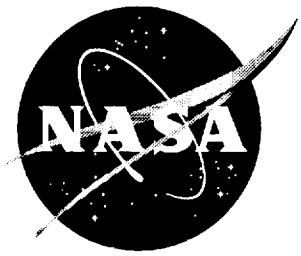
NASA/TM-1998-206925



NASA Image eXchange (NIX)

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Available from the following:

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Introduction

The NASA Image eXchange (NIX) is a meta-search engine (i.e., a search engine that communicates with other search engines) which uses distributed digital image databases to access photographs, animations, and their associated descriptive information. It provides a single entry point to search selected digital image databases at the NASA Centers. NIX, which is an ongoing effort to link the digital image resources of NASA, can be viewed via a world wide web browser and searched at the following uniform resource locator (URL):

http://nix.nasa.gov/

NIX currently accesses selected digital image databases of the following seven NASA Centers: Ames Research Center, Lewis Research Center, Langley Research Center, Dryden Flight Research Center, Johnson Space Center, Goddard Space Flight Center, and Stennis Space Center. The remaining NASA Centers are in the initial stages of implementing digital image databases with search engines that will link to NIX. Several NASA Centers have included animations, digital videos, and digitized film footage in their databases.

This report provides information on the NIX project, explains the method used to create, beta-test, and implement NIX, and gives the technical background for NIX.

Background

Basis for NIX Development

The idea for the NIX meta-search engine (fig. 1) originated from a business process re-engineering initiative by the NASA Scientific and Technical Information (STI) Program. In 1996, the STI Program initiated an extensive Agency-wide customer analysis of its existing services and products with a focus on the need for new approaches and products. The STI Program Office undertook this project after Langley Research Center became the Principal Center for implementation of NASA's STI Program. The NIX effort originated from the need to add nontraditional types of media (such as electronic images, computer animations, video, and film footage) to the STI Program's services and products.

NIX is the prototype and implementation system created by the STI Photographics Subgroup

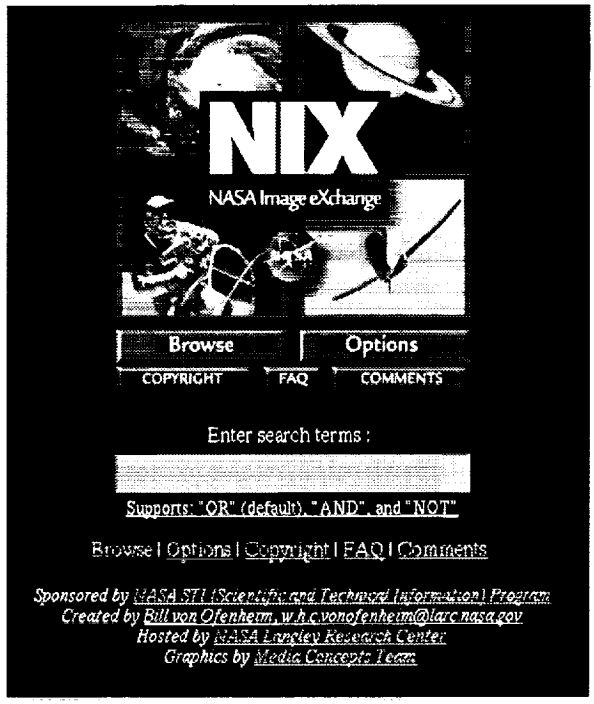

Figure 1. NIX web page with key word search capability.

(appendix A). The Subgroup is a voluntary association of NASA STI, photographic, library, world wide web, public affairs, computer science, and graphics personnel from 10 NASA Centers. The STI Program Office formed the Subgroup in November 1996 with a charter to recommend a prototype to add nontraditional media to the STI Database. The STI Database, which currently contains more than 3 million bibliographic STI citations of interest to NASA, is NASA's primary tool to access STI.

User Requirements

The Subgroup obtained user requirements from the STI business process re-engineering initiative, the Media Services Division of the NASA Headquarters Public Affairs Office, and the STI Program Office. These requirements were as follows:

1. To include NASA's still and moving images that are

   - Electronically available domestically and internationally
   - Key word searchable; images should be output by a search that is ranked in order of how well these images meet the search criteria

- Provided in multiple resolutions

2. To include a system, which can be scaled, that provides these images in a standard image file format and has an intuitive user interface. The system needs to provide the following:

- Search capability
- Catalog of images by heading or subject
- Simple navigation controls

3. To ensure that the Subgroup linked the images to either the STI Database or to the STI home page at URL http://www.sti.nasa.gov/.

NIX Project Phases

STI Photographics Subgroup

The STI Program Office assigned the Lead for the Subgroup. The Technical Lead was assigned through a cooperative arrangement between the STI Program Office and the Langley Research Center Data Analysis and Imaging Branch of the Information Systems and Services Division. The STI Lead Center Information Desk at Langley Research Center provided the logistical support for the distributed team and project. Three NASA Centers originally participated in the Subgroup in November 1996; 10 NASA centers participated by the end of the 6-month charter in May 1997. Because the Subgroup did not have travel funds to accomplish their task, one video conference, weekly and then biweekly teleconferences, and a world wide web page were used to communicate and evaluate information in the virtual environment in which the Subgroup functioned.

The Subgroup, which began in November 1996, gave its final report and recommendations to NASA Headquarters on May 1, 1997. NASA Headquarters approved NIX for release, and the STI Program released it to NASA and the public on May 15, 1997.

Charter for Subgroup

The charter of the STI Photographics Subgroup was twofold. First, the Subgroup was to examine both the existing photographic and image resources in NASA (for example, photographic collections, archives, and retrieval systems) and their future development plans. Second, the Subgroup was to recommend a practical method for improving access to these resources by NASA personnel, outside organizations, and the general public.

The constraints and parameters given to the Subgroup were that the prototype (and a future implementation system) must

- Be cost realistic
- Leverage as much existing hardware and software as possible
- Be realistic to implement by interested Centers
- Have the capacity to be upwardly scaled
- Be flexible enough to utilize existing production and conversion efforts throughout NASA
- Have the capability to be implemented within a reasonable timeframe (6 months)
- Function within the guidelines and standards applicable to the technical area

Two additional goals formed the basis for the formation of the Subgroup. These were as follows:

1. To leverage cooperation among the Centers to NASA's best advantage

2. To share expertise among the Centers regarding how to ensure the quality of information content during dissemination and the technology vehicle used to transmit this content

Project Plan

Prior to the design of the prototype, the Subgroup researched existing databases and software of potential use in the design of NIX. The Subgroup evaluated the advantages and disadvantages of various databases, and these analyses formed the basis for choosing one of the three models for NIX (Model A—Centralized, Model B—Hybrid, and Model C—Distributed). However, because there was no existing example of Model C that met all of the stated requirements, the Subgroup created a model to evaluate.

Subsequently, the Subgroup did initial testing of the prototype, evaluated the results, and added improvements. A customer team of representatives from the public and NASA users was established to beta-test NIX. These users reviewed NIX, and their recommendations were incorporated into the final version.

Identification of Possible System Models

The following section describes the models that were analyzed as possible candidates for the NIX prototype, lists various examples of these models, and discusses the advantages and the disadvantages of each.

Model A—Centralized Model

The centralized model (fig. 2) consolidates all the meta-data and the images in one central repository. (Meta-data is defined as the textual information that describes the image content [e.g., date, title, and description] and image specifications [e.g., resolution and file format of an image].)

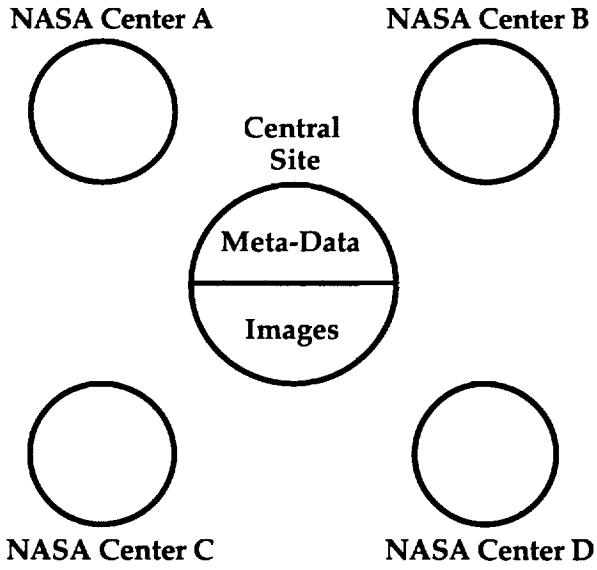

Figure 2. Centralized model.

In the centralized model, each participating Center is responsible for sending meta-data and images to the central repository and updating the central repository whenever the images or meta-data are subsequently modified.

Centralized model examples. Examples of databases and systems that were evaluated and are typical of the centralized model are NASA's RECONplus, PhotoDisc™, Corbis, and the Department of Energy's National Renewable Energy Laboratory Photographic Information eXchange (PIX).

NASA's RECONplus, URL http://www.sti.nasa.gov, is a database of STI that requires registration from NASA's Center for AeroSpace Information (CASI). RECONplus uses telnet, a log-in identification, and a password to access the information.

PhotoDisc™, URL http://www.photodisc.com/index.asp, is a search engine that prompts the user to enter words or image numbers and provides options for displaying the search results. The default is a thumbnail image and a label with a number and a category plus other information. The user may choose to purchase the image with a license or get a free download to their computer.

Corbis, URL http://www.corbis.com, is an on-line stock photographic company that sells images for public use. It has an on-line catalog set up as a browser, which provides menus based on users' selections of the type of photograph they wish to view. The selection ends in a collection of thumbnail images that, when clicked, download the image.

PIX, URL http://www.nrel.gov/data/pix/pix.html, is an on-line collection of images dealing with renewable energy and technology for energy efficiency. The main page provides a link to a search engine that offers a list of terms if the user is unsure of what exact term is needed or a text box if a term is known.

Centralized model advantages. The primary advantage of the centralized model is that it uses a single search engine to provide continuity for the various data fields. This continuity therefore simplifies searching. A second advantage is that each distributed Center or site can avoid the costs associated with the creation and maintenance of their own image repository.

Centralized model disadvantages. There are three major disadvantages of the centralized model. The first disadvantage is that it is very costly to staff, construct, maintain, and upgrade a central site. The second disadvantage is that this model has a low failsafe capability, because if the central system or a major component fails then the entire system is inaccessible. The third disadvantage is that in all probability, each Center will still maintain its own image repository for reasons relating to control and autonomy, thereby negating the second advantage.

Model B—Hybrid Model

A hybrid model (fig. 3) is similar in concept to the centralized model except that only the meta-data is transferred to the central site.

Hybrid model examples. Examples of databases and systems that are typical of a hybrid model are NASA Galaxie and LYCOS®.

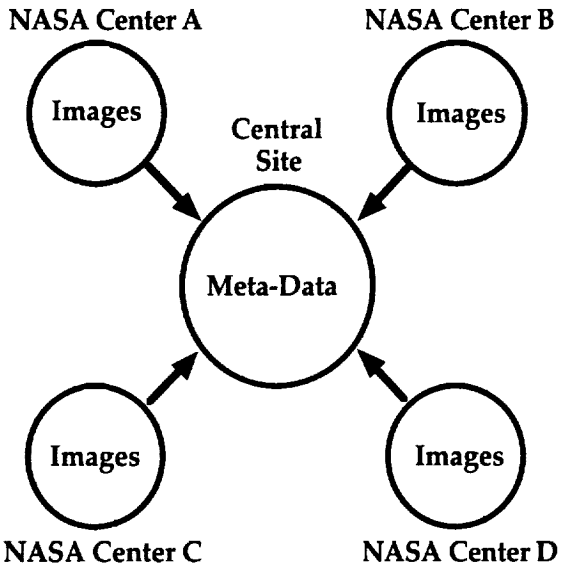

Figure 3. Hybrid model.

NASA Galaxie (previously called STILAS) is a combined browser/search engine, which can be found at URL http://stilas.larc.nasa.gov/.

The system prompts the user with text instructions and graphical menus to choose a search type or a browse category and then returns a numbered list. The user then clicks each item to display more information. Users must be registered at a NASA library to access NASA Galaxie.

LYCOS®, URL http://www.lycos.com/lycosmedia.html, is a search engine that pulls data from other databases according to the criteria entered by the user. The user enters a word or phrase into the text box provided, and LYCOS® then returns a list of results. The user can click the title of each image to obtain a full-page image or a small GIF image, depending on what the image is. Images cannot be downloaded, and no other information about the image is available.

Multiple variations exist of the distributed model. One variation is to include thumbnail-sized images on the central site. Another variation is to include thumbnail- and screen-sized images on the central site, thus leaving high-resolution images at the individual Centers.

Hybrid model advantages. The advantages of the hybrid model are the same as those of the centralized model, but without the need for infrastructure to support the large quantity of data associated with digital images. Therefore, the hybrid model is less costly than the centralized model, because the requirements and need for housing large image files are not an issue. Also, modifications made to the images will not have to be transferred to the central site.

Hybrid model disadvantages. Disadvantages of the hybrid model are similar to those of the centralized site except that the redundancy is not as great, because only the meta-data needs to be replicated. Similar to the centralized model, this model also has a low failsafe capability, because if any component in the central system fails, the entire system is inaccessible.

Model C—Distributed Model

The distributed model (fig. 4) is the opposite of the centralized model, because it leaves the images and meta-data at the individual Centers and utilizes a virtual central site that communicates with each of the individual sites. This virtual central site understands the dialect (or search engine protocol) of each of the individual Center's databases and communicates with each Center's database using that specific dialect. Incorporated into the virtual central site are several protocols in order to support searches from a diverse collection of database engines. Searches are performed in parallel to ensure optimization of response times.

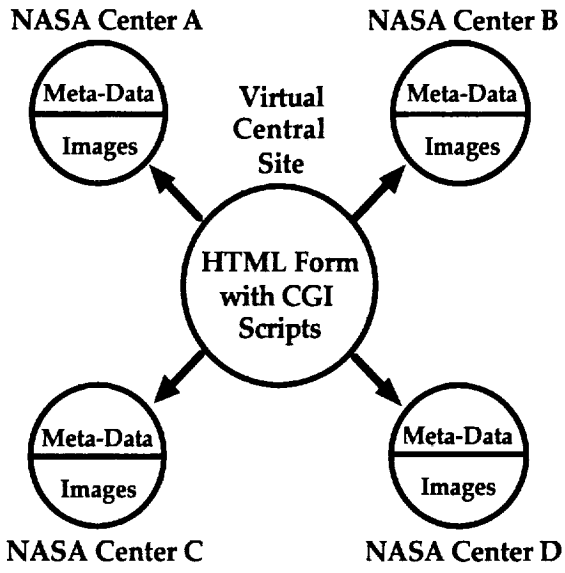

Figure 4. Distributed model.

Distributed model examples. An example of a distributed model database is the NASA Technical Report Server (NTRS). The NTRS (URL http://techreports.larc.nasa.gov/cgi-bin/NTRS) is a search engine that allows the user to retrieve NASA technical reports by entering words or phrases and selecting the databases to search from a list provided on the search page. The NTRS returns the results in groups from each database searched, and scores and sorts (i.e., ranks) them according to how well they match the search criteria. The user can click the title to access a page with more information and an abstract of the report. If the title is a link, clicking it allows the user to electronically download the report.

Because the Subgroup could not locate a suitable example of the distributed model that related to digital images, a prototype was created to evaluate. This prototype, after evaluation by customers and subsequent modification, became NIX.

Distributed model advantages. Advantages of the distributed model include that there is little or no interference with each Center's existing image repositories. Therefore, this model is much more attractive regarding the use of existing resources of the Centers. No extra expense is involved with development of the infrastructure to maintain this model. There is no extra hardware expense for the Centers above and beyond what they currently provide for their local database. No redundancy exists as it did in the previous two models. Since the originals and negatives of the images remain at the original Center, control of images and meta-data remains distributed. No duplication of images exists. In addition, this model does not require transferral of images or update of duplicates; therefore, the images and meta-data will always match. The distributed model has a higher ability to be failsafe for two reasons:

1. A failure at a distributed site will not "bring down" the entire system. In fact, the entire system will function as before except for the loss of results from the site that went down.

2. A failure at the virtual central site will cause a temporary lapse in service which can easily be rectified by moving the site to another server. This is possible because the virtual central server is trivially small (consisting of just CGI [Common Gateway Interface] scripts without the burden of meta-data files or large image files).

Distributed model disadvantages. The major disadvantage of the distributed model is that it interfaces with a wide variety of very different databases, each with its own unique protocol for specifying a search query and also its own unique result format. This greatly increases the complexity of the development and maintenance of the system. In addition, there is a difficulty in logically ordering the results of the searches (i.e., logically collating the results from each of the Centers and resolving the ranking differences), because of the varying sizes of the image collections at the distributed Centers.

Selection of system model. After evaluation and analysis of the advantages and disadvantages of the three potential models, the Subgroup chose the distributed model on which to base NIX. The key factors that influenced the decision included minimizing impact to individual Centers and minimal cost. All of the constraints and parameters originally specified in the Subgroup's charter were also satisfied by this choice.

NIX Capabilities

As the prototype for the distributed model evolved into the production version of NIX, it acquired additional capabilities to accommodate users who had various degrees of knowledge and search expertise. These capabilities included two search schemes that are augmented by online user information and a staffed help desk.

Search Capabilities

Features of the NIX search capabilities include both key word and browse search options.

The key word search (fig. 1) allows the user to search the meta-data associated with the image in the numerous fields available in the meta-data, such as description, title, image number, and other descriptive information. This key word search can be refined through the use of selected Boolean operators, such as AND, OR, NOT, precedence (explicit ordering using parentheses), and wild card characters (word completion capabilities) to create a query string (fig. 5). NIX passes the query string directly to each distributed database for processing by the search engine that is resident on that distributed machine. The search engine on the distributed machine has the

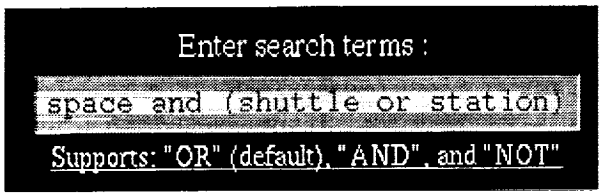

Figure 5. Query string.

responsibility for correctly parsing the query string and performing the requested search. Tips for searching with Boolean operators (fig. 6) are included in NIX. (Note: The full text of the search tips is given in appendix B.)

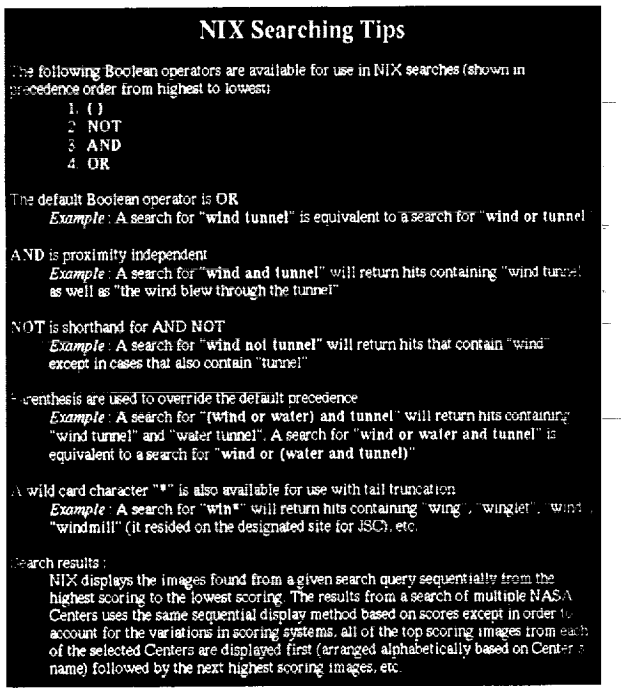

Figure 6. Tips for searching NIX with Boolean operators.

An inherent problem associated with key word searches involves the ranking or scoring of the returned "hits" to indicate the closest matches. This problem is a manifestation of the dichotomy of the originating data since these data consist of two separate (although hopefully related) pieces: the image and the meta-data. Key word searches only deal with the meta-data "piece," and so the quality of the searches is limited by the quality of the meta-data. For instance, if the quality of an image's meta-data is poor (e.g., a scanty or nonexistent description), then the probability that this image will be found through a key word search is low. Conversely, if the quality of the meta-data is high, then this image will have a high probability of being returned from a key word search even though the image quality may be poor. To further complicate the issue, the measurement of "quality" for the meta-data is highly subjective and depends on one's perspective. From a user's perspective, the "quality" could be dependent upon factors such as completeness and comprehensibility. However from a database's perspective, the "quality" metric is typically based on frequency of a word's occurrence. So an image's meta-data that is complete and understandable may mention a key word only once and therefore the image would receive a low ranking when searching for that particular key word. On the other hand, an image's meta-data that is incomplete and unintelligible but repeats the key word multiple times would receive a high ranking. In order to minimize this problem, NIX also provides a browse search capability.

The browse search (fig. 7) is a prebuilt key word search on a particular subject or category. Each browse page, which represents one category, is owned and served by a Center (usually determined by the Center's mission and expertise). The Center responsible for the browse page has knowledge of the subject area as well as of the images representative of this area of expertise. Application of this knowledge provides higher quality results than would be possible via key word searches. Note that although a given Center has the responsibility for a particular browse category, the images contained in the category may come from a variety of Centers. Since browse categories are

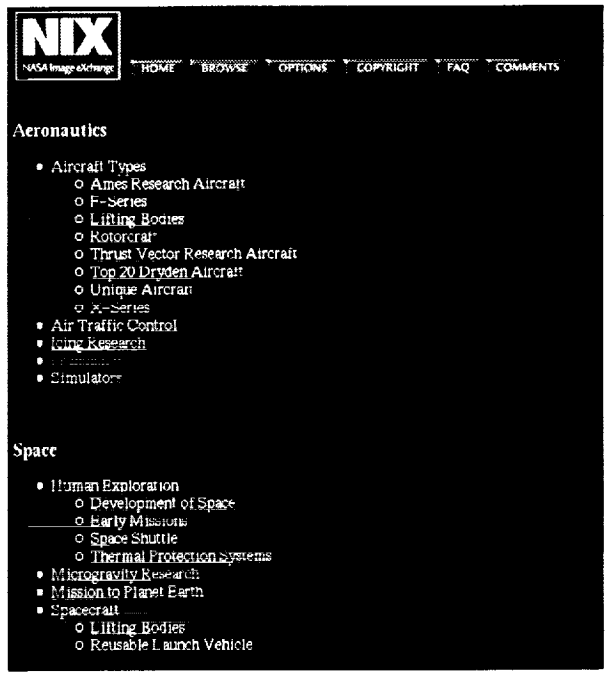

Figure 7. Browse search capability.

designed to be the best representative images for that category, it makes logical sense not to limit the images to those from the responsible Center but to include any relevant images that may reside elsewhere. The complete list of browse categories is given in appendix C.

Because of the distributed nature of the browse pages and to achieve uniformity and consistency, a web-based "Browse Page Builder" has been developed for adding new browse categories to NIX. This Builder provides a simple interface via a web form for specifying the title of the browse category, responsible center information (e.g., point of contact, name of center, and email address), and the list of included images. The Builder returns a completed HTML (HyperText Markup Language) document that is formatted to the NIX specifications; this formatted document can then be copied to the distributed machine and served by the particular web server. The Builder is a CGI script written in Perl (Practical Extraction and Report Language) that uses file uploading to transfer information from the distributed Center. It uses *a priori* knowledge to determine the location of the image based solely on the entered image/photo number and derives the necessary URL's for thumbnail images, screen resolution images, and additional information.

Information in NIX for Users

The STI Photographics Subgroup intended for NIX to be user friendly and self-explanatory. Therefore, the Subgroup added several features that would allow both first-time and repeat users of NIX to use the search capabilities equally easily and successfully. The Subgroup added sections concerning frequently asked questions (FAQ), copyright information, and comments (i.e., a Comment form) supported by a help desk. In addition, the web page was designed to provide users with a simple interface for multi-platform computer environments as well as web television environments. One example of NIX's design for multiple environments is that the width of the primary world wide web page is narrower than the typical pages to accommodate television monitors.

Frequently asked questions. The FAQ button returns a description of and intent for NIX, describes the databases that a user can access through NIX, and gives the approximate number of images that are accessible (fig. 8). It also describes the browse category button, how to do a text-only search without

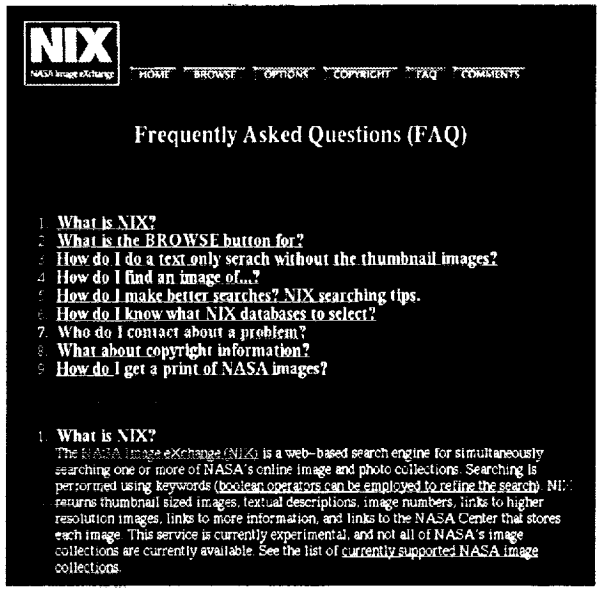

Figure 8. Frequently asked question section.

the thumbnail images, how to find images, how to conduct a better search, and how to determine which databases to search. The FAQ gives a description of the currently linked databases and what they contain. It also gives contacts for more information, additional tips for better search strategies, information about copyright requirements, and how to get prints of some NASA images. The FAQ refers users to additional photographic archives that do not have search engines but that house additional photographs in NASA. The text of the FAQ web page is given in appendix B.

Copyright information. The Copyright button displays the general conditions under which a customer can use NASA digital images (fig. 9). It also describes restrictions on photography and gives a contact for additional information. The text of the copyright information from the web page is given in appendix D.

Comments/questions section. NIX includes a NIX Comments/Questions section (fig. 10) that sends users' comments/questions to the STI Lead Center Information Desk at Langley Research Center for assistance. This help desk either assists the user if the inquiry concerns NIX and the distributed image repositories or refers technical questions to the appropriate technical contact for NIX at the various Centers. If the comment concerns a problem with NIX or NIX meta-data, the help desk forwards the comment to the appropriate NASA Center, obtains a reply from that Center, and notifies the customer of the action taken by NASA.

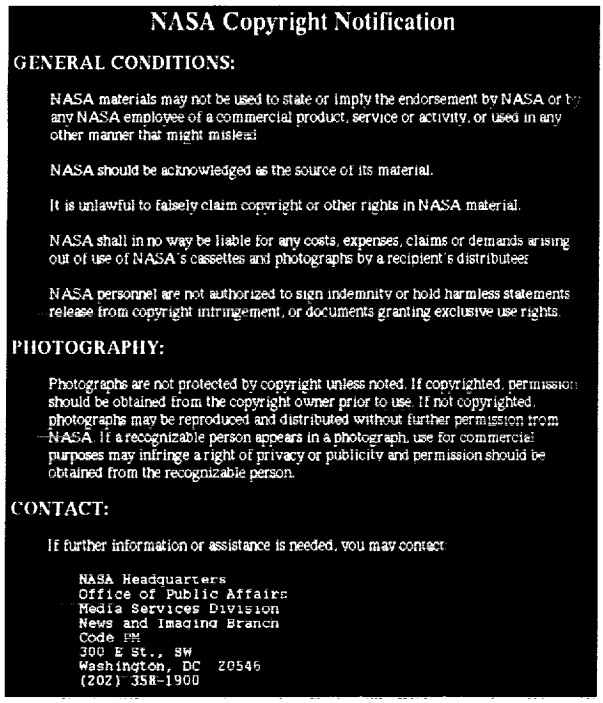

Figure 9. Copyright notification information.

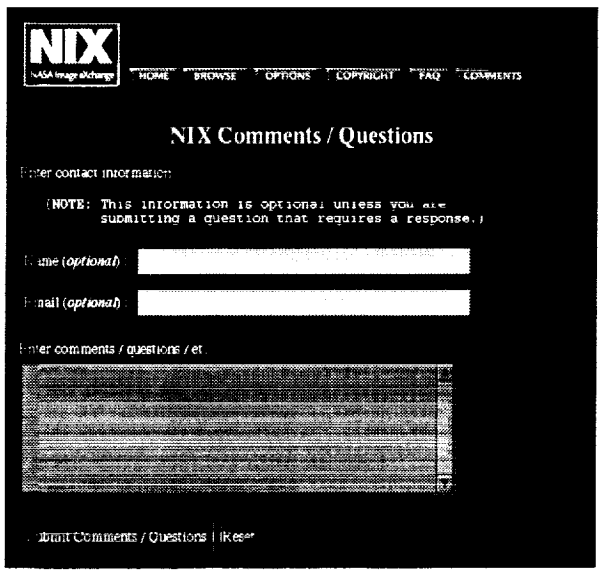

Figure 10. Comments/Questions button.

The majority of questions received have been on such topics as "Where can I find a picture of...?" The help desk answers these inquiries by (1) doing a search of NIX, (2) searching image databases at the specific Center that has the most expertise in the inquiry area, (3) searching image databases or collections that are not currently a part of NIX, and (4) searching other available resources. A sample of the types of questions being handled by the help desk is given in appendix E.

Technical Design of NIX

NIX Technical Overview

NIX is a CGI script that is written in Perl. Several publicly available libraries/modules are utilized by the script to provide forms processing (cgi-lib.pl), WAIS (Wide Area Information Search) functionality (Wais.pm), and HTTP (HyperText Transfer Protocol) capabilities (libwww.pl).

As indicated by the libraries, NIX is designed to support two different search mechanisms: WAIS and HTTP. The WAIS protocol, which is based on a subset of the ANSI (American National Standards Institute) standard Z39.50, provides an efficient method for directly communicating with a WAIS server on a remote machine. In fact, the WAIS servers associated with NIX have been optimized to return all the information relevant to NIX (i.e., URL of thumbnail image, URL of screen resolution image, and URL of meta-data, title, and image number) through the WAIS headline, thereby avoiding the "return trip" cost of accessing the individual indexed documents. HTTP is the standard web protocol, and is used as an indirect method to get access to non-WAIS databases, such as an SQL (Structured Query Language) database running on a Macintosh. The HTTP protocol is used to communicate with the remote web server, which in turn, communicates with the underlying database. Because of this level of indirection, HTTP-based searches are not highly efficient, but what they lack in performance is made up for in flexibility.

Regardless of the search mechanism, NIX performs searches in parallel. A serial search (in which each database is queried in turn) would lead to unacceptably long response times, and the problem would be compounded as new databases are added. Parallelism, as implemented in NIX, is accomplished by forking a single child process for each database to be searched. (Note: Perl does not currently support threads.) The child process is then responsible for sending the search query to the database that it is responsible for and assembling the results returned for delivery to the parent process. The parent process accepts responses from its children in an asynchronous fashion to eliminate any co-dependencies.

In the event that a remote server is either very slow or hung, an added failsafe mechanism has been incorporated into the child processes to provide a "guaranteed" response time. The mechanism is a timer that terminates the child process if the response to the search query is not received in the allotted time. The timer is set to 15 seconds by default, but the NIX user can modify this default value. (See the "Options" button in NIX.) The parent process ignores all children with expired timers so that it will not stall; however, the databases associated with the terminated children will be posted with the results so that the user can optionally modify the timer's duration to encompass more hits.

To preserve state information and to avoid having to redo the search as the user advances from one page of search results to another, NIX assembles the search responses returned by the child processes and stores this information in a temporary file. The lifetime of a temporary file is at least 4 hours, which is accomplished by a crontab job running at regular intervals to check the creation times of all temporary files and then to delete the ones that have exceeded the threshold. In the event that a user's search session spans more than 4 hours, there is sufficient information in the URL associated with each page of results to redo the search and create a new temporary file.

The work required to regenerate the search is far more than the toll exacted through file I/O (Input/Output) when assessing the temporary files, so this caching scheme has proved effective.

An additional CGI script was created to support the remote generation of NIX browse pages that fully conform to the specifications of the NIX interface. This script provides an easy method for each Center to generate and update browse pages without any programming expertise. The script, as previously mentioned, is called the "Browse Page Builder" (URL http://nix.nasa.gov/nph-browse.cgi). The Builder operates through the use of file uploading.

The script for the Builder uses "server push" to provide immediate feedback regarding the progress; this occurs by indicating which image it is currently working on and the outcome of the work. Since each Center uses a unique image numbering scheme, the script can easily determine which Center has the desired image, and a search is performed of that Center's database to validate that the image exists there and to derive the information relevant to NIX (see above). If all images are found, then the script displays the results in a web document that conforms to the NIX standards. This document can then be saved to the Center's machine to be served by the Center's local web server. The NIX webmaster only needs to be notified when any new browse categories are created so that the URL pointing to the saved document can be added to NIX's list of browse categories along with the title of the browse category. If one or more images cannot be found, the script highlights their image numbers in red so that it is obvious to the user where the problems are. The normal course of action in this case would be to do a search through NIX to find the correct image numbers and start the process over again.

Minimum Requirements to Link to NIX

NIX uses a meta-search engine that accesses the internal searchable photographic databases (each with different search engines) of the various NASA Centers. Therefore, minimum requirements exist in order for NIX to link to a Center's database. The STI Photographics Subgroup kept these requirements to a minimum so that the Centers did not have to add personnel or funding. The minimum requirements that are required to link to NIX are as follows:

1. A searchable database must exist that allows the program to derive the following information:

- URL for thumbnail image (maximum width of ~100 pixels and height of ~100 pixels). To improve system performance, the width and height in pixels should be provided.
- URL for screen resolution image (width of ~640 pixels and height of ~480 pixels)
- Image/photograph identification number
- Title or brief description
- URL for additional information, such as complete meta-data, additional image resolutions, and any site specific information

2. Each image in the database needs to be available in the following two resolutions with preserved aspect ratios:

- Thumbnail in either JPEG or GIF
- Screen resolution in JPEG

Image Repository Standards

The STI Photographics Subgroup recommended the following appropriate standards for image repositories. Requirements include the following minimum standards:

1. Thumbnail-sized image, which is optimal for fast downloading and for providing an approximation of image content

2. Standard screen resolution, which is ideal for on-screen viewing

3. High resolution, which should include the following:

- Images that are approximately 1k × 1.5k or 1k × 1k, which is ideal for screen savers and background images
- Images that are approximately 2k × 3k or 2k × 2k, which is adequate for high-quality printers
- Images that are approximately 4k × 6k or 4k × 4k or greater, which is necessary for high-accuracy analysis, image preservation, and posters

4. Captions for the image for identification purposes. Potential items to be included in a caption are as follows:

- NASA identification and/or logo
- Center identification and/or logo
- Image identification number
- Short description

5. Image formats that are recommended include the following:

- JPEG. This is the most popular method of distribution because it will provide a 1:10 to 1:40 compression, and virtually all image display software supports it. A compression of 1:20 (or medium quality) works best for printing purposes and reducing file storage sizes.
- TIFF or TIF. These formats (TIFF for Macintosh and TIF for PC) are the defacto format for printing since all printers have the drivers necessary to use them. These formats should not be compressed because opening the file often requires use of the software with which it was compressed. If these formats are compressed, the home page should cite the software and the version that were used to compress the files. This format is not recommended because it is large, requires long downloading times, and cannot be viewed by browsers in default configurations.
- GIF. This format works well for graphics-type images. It reproduces large areas of the same color without any defects. (JPEG is not recommended for these types of images.)
- Photo-CD. This format provides five or six image resolutions. An area of concern is that when distributing on the Internet, the entire file is sent (not just the requested resolution) unless the server has software specifically designed for this task.
- Photo-PIX. This is a format that may become an imaging standard in the future. Caution should be used until it does become the standard.

6. Meta-data. This should include the following:

- Full description (searchable)
- Title or brief description (searchable)
- Key words (searchable)
- Image/photograph number(s) (searchable)
- Date of creation (searchable)
- Image information, such as:

  Format
  Dimensions
  Size
  Location
  Other identification numbers

- Related publication(s) link

7. Indexing. Ideally a qualified library scientist should be involved in reviewing and/or providing the meta-data entries to ensure compliance with the *NASA Thesaurus* (URL http://www.sti.nasa.gov) for appropriate and consistent key word selection

8. Site capabilities. These should include

- FreeWAIS-sf database accessible for remote searches
- Sufficient information in the freeWAIS-sf headline to derive :

  URL for thumbnail
  URL for screen-resolution image
  Image/photograph number
  Title or brief description
  URL for additional information

NIX Beta-Test

NIX was intended to be user friendly and accessible by the public as well as by NASA personnel. This meant that NIX needed to be designed for a wide array of different computer platforms, operating systems, and Internet connection conditions. Therefore, the Subgroup beta-tested the NIX prototype with an Agency-wide and external customer team to obtain feedback; this feedback then formed the basis for revisions to NIX.

The customer team was a distributed team that included representatives from outside NASA, from a previously used customer team formed during an STI Lead Center Business Process Re-engineering initiative, and from NASA Centers. The Subgroup asked volunteers to access and search NIX during a specific timeframe and to complete a simple on-line survey form. The Technical Lead designed a computer program that automatically tabulated and displayed the results on a web page for review by the STI Photographics Subgroup.

Customer Evaluation Survey

The NIX survey (fig. 11) included 11 questions; the survey asked customers to use NIX and rate it based on a rating scale from 0 to 5. (The value 0 indicated no opinion, 1 indicated strong disagreement, and 5 indicated strong agreement.) The users rated NIX by clicking the appropriate button in the survey field. The survey also included a comments field so that users could give additional subjective information, if they desired to do so.

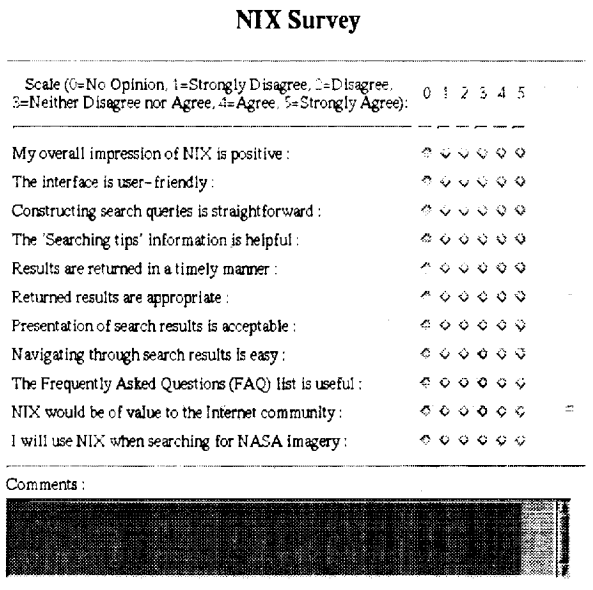

Figure 11. NIX survey.

A web page displayed the survey results to the Subgroup; these results included responses to the original questions, results rated by each customer, and miscellaneous comments. Twenty-two of 38 customers responded to the survey. The average score for all questions was 3.6; the highest averaged score registered was 4.4. (The 4.4 score related to the statement "NIX would be of value to the Internet community.") The low score registered was 3.5. (This score related to the statement "Returned results are appropriate.") Notable initial positive comments included that "NIX would be a great tool for users" and being "...amazed at how quickly your search engine went through all the databases." Users noted the following areas that needed improvement:

- Additional Centers should be linked to NIX
- More images are needed on a greater array of subjects
- More consistency is needed concerning key words that are assigned to the images
- An explanation is needed of why various subjects did not return the required hits

After gaining feedback from the customer survey, the Subgroup addressed as many comments from the customer survey as possible within the timeframe and then modified NIX. Several areas (FAQ and browse categories) were modified and reevaluated to ensure that improvement had been achieved.

NIX Implementation and Public Awareness

The STI Photographics Subgroup intended for the widest dissemination of NIX once NASA Headquarters approve its release. To this end, the Subgroup, in coordination with the NASA web-masters, linked NIX to the STI Program's web page at URL http://www.sti.nasa.gov/ and to the NASA PhotoGallery at URL http://www.nasa.gov/hqpao/library.html/photo/index.html.

It also linked NIX to all except one of the NASA Centers' home pages and to all standard web search engines and web groups for release to the public. The NASA Headquarters Public Affairs Office sent notices to the Centers' Public Affairs personnel to notify of the release of NIX. The Subgroup also listed NIX in

Today@NASA and sent press releases to NASA programs.

All members of the Subgroup (appendix A), which were originally chartered for 6 months, volunteered to continue with the NIX project. The Subgroup determined that the biweekly teleconferences could be discontinued, but that it would be helpful to maintain an email alias to discuss issues related to NIX. Technical contacts (see FAQ 7 in appendix B) at each of the Centers continued to handle system and server technical inquiries and questions.

Usage Statistics

A statistical analysis has been performed on the first 6 months of the NIX access logs to obtain answers to the following questions:

- How much is NIX being used?
- When is NIX being used?
- What parts of NIX are being used?
- Where are the customers coming from?

Figure 12 shows the number of page views on a monthly basis. A "page view" was chosen as the preferred metric because a "hit" includes graphics (e.g., logos and buttons) and image downloads that unfairly augment the perceived usage rates. For 5 months out of the 6, usage was fairly uniform, and it hovered around 95,000 page views per month. The exception occurred in July 1997 when usage increased by 70%. The probable explanation for this spike was the surge of interest in NASA activities generated by the *Mars Pathfinder* mission.

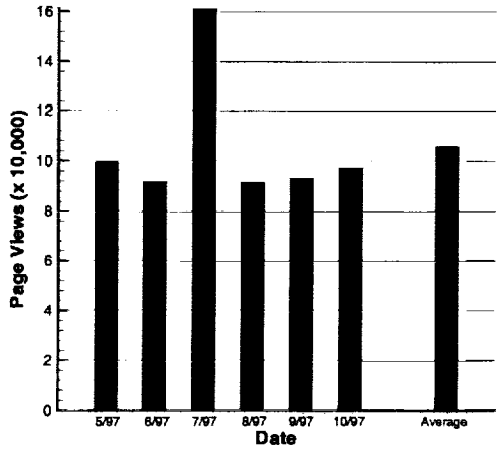

Figure 12. Number of page views on monthly basis.

Figure 13 displays the average number of page views on an hourly basis. High usage rates occur between 11 am and 5 pm Eastern StandardTime (EST), which represents the workday overlap between the east and the west coast (11 am to 5 pm EST equates to 8 am to 2 pm Pacific Standard Time PST).

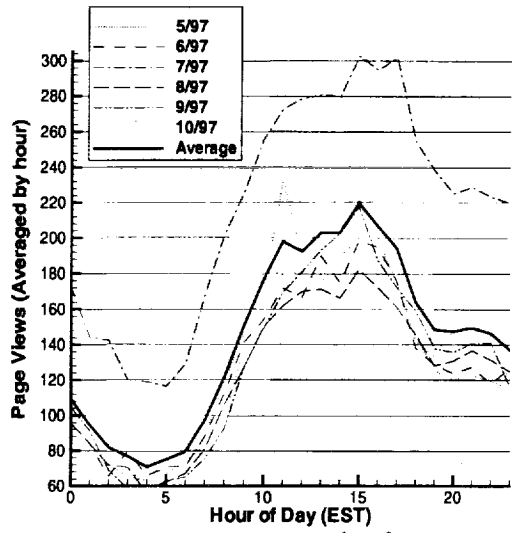

Figure 13. Average number of page views on hourly basis.

The two primary elements of NIX are search and browse. Figure 14 indicates the relative usage rates for these two elements on a monthly basis. It is readily apparent that the search function has a far higher usage rate, which is probably because of its prominence on the main page and the slow development of relevant browse pages. Appendix F provides a list of the words used most frequently in a search and the frequency of their use. These search words are currently being used

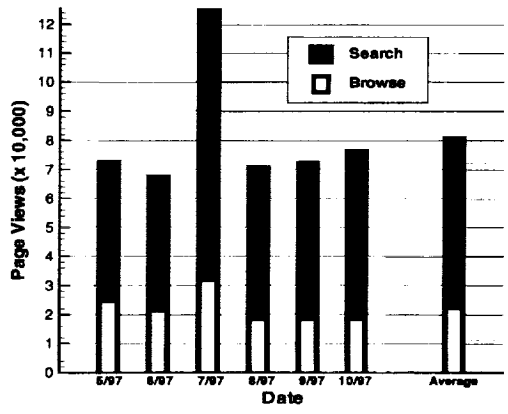

Figure 14. Relative usage rates of search and browse capabilities on monthly basis.

to create new browse pages to remedy the search imbalances.

Finally, figure 15 depicts the usage by domain names over the 6-month period. Not surprisingly, the bulk of NIX users came from the ".com" (companies) domain, which is the most populated domain level. For the remainder of the domains, the usage rates closely correspond to the rank of the domain based on the number of supported hosts. The two most significant deviations are the ".edu" (educational) and ".gov" (government) domains. The ".edu" usage rate was much lower than its ranking, but this is probably due to the inclusion of the summer break in the 6-month sampling period. The ".gov" usage rate was much higher than its ranking, which is invariably due to the direct relevance of NIX to the needs of individuals coming from the ".nasa.gov" domain.

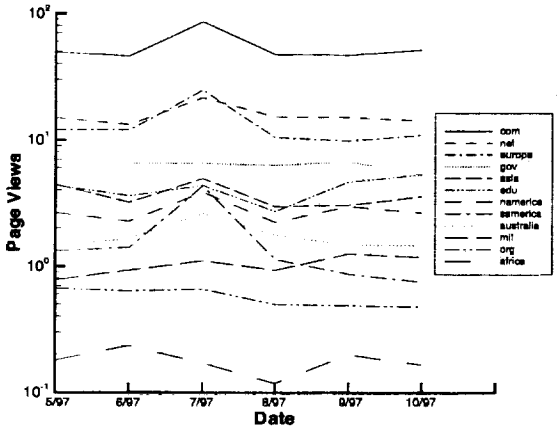

Figure 15. Usage by domain names for 6-month period.

NIX Expansion

NIX Technical Assistance to Centers

The STI Program Office, through funds from the NASA Headquarters STI Program, is providing technical and other resource assistance to the Centers (appendix G). In 1997, four Centers received one-time, time-limited monies to either (1) expand the current scope of NIX at their Centers or (2) establish a framework at their Centers to link to NIX. In 1998, four Centers received assistance to either provide an initial link to NIX or expand the scope of NIX. Additional technical support was provided to two Centers to upgrade equipment necessary to maintain the NIX search quality and turnaround time requirements of the distributed system.

Improvement Recommendations

The Subgroup recommended the following short- and long-term improvements for NIX:

Short-term recommendations. Short-term recommendations included the following:

1. Continue Agency NIX group and an email alias
2. Continue technical assistance among the Centers
3. Expand the photographic databases for NIX and add additional sites
4. Establish minimum standards and technical aspects
5. Provide indexing of new images through the use of the *NASA Thesaurus*; include library science personnel in this process
6. Gain advocacy from Centers' and NASA Headquarters management
7. Expand NIX features (e.g., browse capability, synonym file, monthly Public Affairs Office image sampling, and information on missions of Centers/Center-of-excellence information)
8. Address the security issues of photographs and distributed systems
9. Establish a policy for thumbnail-sized photos; address the use of CD auto-conversion and size issues
10. Continue/get webmaster support at the Centers
11. Link to other web pages for awareness (such as web home pages at the Centers and the NASA home page via *Today@NASA*); register with search engines, notify webmasters, request that image repositories point to NIX, and send information on NIX to Internet advisories
12. Establish a user support framework (help desk), possibly through the STI Lead Center Information Desk at Langley Research Center
13. Examine the process to digitize Centers' public affairs and historical photos
14. Re-address design issues regarding the NIX main page (e.g., black background, rotating photos, color of visited links, width of design, NASA insignia, interlaced GIF images, frequently asked questions, Center-of-excellence issues, and text-based browser issues)
15. Monitor usage of NIX and incorporate feedback into subsequent NIX changes

16. Address technical needs at the distributed image repositories, such as hardware upgrades or public servers

Long-term recommendations. Long-term recommendations included the following:

1. Begin a major expansion of images into NIX

2. Move toward Agency standards for indexing, sizes, resolutions, and photographic meta-data

3. Establish an interface to gain additional photos and add video

4. Document and leverage NIX technical lessons learned via possible NASA Technical Memorandum

5. Examine the issue of archiving images for the National Archives and Records Administration (NARA) and determine how it applies to NIX

6. Establish policy for high-resolution images

7. Re-examine who NIX customers are (e.g., public, NASA, or both) to ensure that NIX is user friendly for the intended audience

8. Provide a framework for implementation across the Agency

9. Determine how and when to add video (MPEG, Quick-Time™, and streaming video technology and their associated technical and procedural issues)

The plans for NIX in the future are to include and expand the number of images from significant image collections of NASA, to link all NASA Centers, and to include a variety of multimedia and developing technology. Efforts will also be made to improve the quality of the meta-data so that search results will be reliable and efficient for users with varying levels of expertise.

Summary

This paper discusses the technical aspects of and the project background for the NASA Image eXchange (NIX). NIX, which provides a single entry point to search selected image databases at the NASA Centers, is a meta-search engine (i.e., a search engine that communicates with other search engines). It uses these distributed digital image databases to access photographs, animations, and their associated descriptive information (meta-data).

NIX is available for use at the following uniform resource locator (URL):

http://nix.nasa.gov/

NIX, which was sponsored by NASA's Scientific and Technical Information (STI) Program, currently serves images from seven NASA Centers. Plans are under way to link image databases from three additional NASA Centers. Images and their associated meta-data, which are accessible by NIX, reside at the originating Centers, and NIX utilizes a "virtual central site" that communicates with each of these sites. Incorporated into the "virtual central site" are several protocols to support searches from a diverse collection of database engines. The searches are performed in parallel to ensure optimization of response times. To augment the search capability, browse functionality with pre-defined categories has been built into NIX, thereby ensuring dissemination of "best-of-breed" imagery. As a final recourse, NIX offers access to a help desk via an online form to help locate images and information either within the scope of NIX or from available external sources.

Appendix A

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Appendix B

Text of Frequently Asked Questions (FAQ) from NIX

Home - Browse - Options - Copyright - FAQ - Comments

Frequently Asked Questions (FAQ)

1. What is NIX?
2. What is the BROWSE button for?
3. How do I do a text-only search without the thumbnail images?
4. How do I find an image of...?
5. How do I make better searches? NIX searching tips.
6. How do I know which NIX databases to select?
7. Who do I contact about a problem?
8. What about copyright information?
9. How do I get a print of NASA images?

Note: This is the exact text from the web site. Underlined phrases are hyperlinks.

1. What is NIX?

The NASA Image eXchange (NIX) is a web-based search engine for simultaneously searching one or more of NASA's online image and photo collections. Searching is performed using key words. (Boolean operators can be employed to refine the search.) NIX returns thumbnail-sized images, textual descriptions, image numbers, links to higher resolution images, links to more information, and links to the NASA Center that stores each image.

This service is an initiative sponsored by the NASA STI Program toward linking many existing photo databases in NASA. Currently, not all NASA photos are online, and not all NASA photo databases are linked to NIX. Minimum technical standards for a photo database must exist at a Center for it to be linked to NIX to enable NIX's search engine to be active. An Agency Subgroup is working to increase the scope and number of photos in NIX. See the list of currently supported NASA image collections.

Currently, NIX searches databases of over 300,000 NASA images.

A more complete listing of NASA on-line image, video, and audio collections is maintained by the NASA Headquarters Public Affairs Office.

2. What is the BROWSE button for?

Many of NASA's best photos may be quickly accessed by selecting the Browse link. Each category is chosen to represent the broad scope of NASA research activities and contains pre-selected images that are considered the "best-of" for that topic. Think of this as a pre-built search to get some of the best images that NASA has to offer on selected topics.

3. How do I do a text-only search without the thumbnail images?

When using slower Internet links to NIX (such as modems), downloading of the thumbnail images may take a significant amount of time.

On the NIX OPTIONS page, there is a button to disable the downloading of the thumbnails on the results pages. The search results page will only contain the text portion of the normal NIX results.

Alternately, you may disable the automatic loading images on your browser. This option is configured differently on each different browser for each platform. For Netscape 3, deselect "Auto-Load Images" in "Options" pull-down menu. For Internet Explorer 3, deselect "window" in the "View" pull-down menu.

4. How do I find an image of...?

If NIX does not produce the information you were seeking, then:

1. See NIX Searching Tips.

2. Ask the NIX Help Desk for assistance.

3. Go directly to a specific Center's site in order to take advantage of more advanced search capabilities and to view site specific browse categories. Yahoo!, etc.

4. If you are certain that the information should be available on one of the NASA servers, please contact the NIX maintainers of the site for assistance where you feel the information should be located.

5. Check any of the Internet search engines such as AltaVista, Infoseek.

5. How do I make better searches? NIX searching tips.

- There is an implied logical "OR" operator for multiple word searches. A search for "wind tunnel" is the same as a search for "wind OR tunnel," which may or may not be what you intend for the search.
- The logical operators "AND," "OR," and "NOT" are available. To search for images of a thrust vectoring F-18 aircraft, use the search terms "thrust AND vectoring AND F-18."
- The wild card "*" is available for word tail truncation. A search term "win*" will return hits containing "wing," "winglet," "wind," "windmill," and other words beginning with the string "win."
- Please see Additional NIX searching tips for more detailed assistance.
- Remember, when searching large databases, it may not immediately return the results you were looking for. Have patience and keep trying.

6. How do I know what NIX databases to select?

The following NASA image servers are part of NIX. The description may be used to help provide a more accurate and efficient search.

Center and Description

Ames Research Center (ARC)

The Ames Imaging Library System (AILS). Ames Research Center specializes in aeronautical computation, experimentation, simulation, and information sciences.

Dryden Flight Research Center (DFRC)

The Dryden Research Aircraft Photo Gallery contains images and video clips of NASA research aircraft dating from 1946 to the present. It includes the X-1, X-15, X-29, X-31, X-33, SR-71, Space Shuttle, F-14, F-15, F-16XL, F-18, and others. It currently contains over 900 images in multiple resolutions and 65 video clips.

Formats include JPEG images and MPEG and Quick-Time™ video clips.

Goddard Space Flight Center (GSFC)

The Goddard Photographic Image Retrieval System (GPIRS) is currently the repository for all Goddard events material. This includes flight hardware and components, spacecraft testing, research and development projects, scientific instrumentation, portraits, groups, awards, VIP tours, public speakers, lectures, other Goddard functions, Goddard buildings and facilities, and a limited selection of flight film and space images.

Johnson Space Center (JSC)

The JSC Digital Image Collection contains more than 260,000 press release and Earth observation images from the manned space program from Mercury to the present. All press release images (c. 10,000 image files) are currently on-line. The recently expanded Earth Observation database now contains approximately 250,000 images with catalog data, ranging from the first shuttle mission, STS-1, to STS-76, which flew in March of 1996. More missions will be added. Johnson Space Center is NASA's primary Center for human spaceflight and astronaut training.

Langley Research Center (LaRC)

The Langley Image Scanning, Archiving, and Retrieval (LISAR) provides a database of photos documenting NASA and NACA research at Langley Research Center. Photos include: aircraft structures, aircraft design, aircraft models, wind tunnel tests, materials research, space programs projects, and historic events. The archive contains over 1000 images with each image available in multiple resolutions including full resolution (up to 5k × 6k) and formats including GIF, JPEG, and TIFF.

Lewis Research Center (LeRC)

The Lewis ImageNet contains still images of general interest produced at Lewis Research Center, along with internal and external links to other NASA image resources. Selections range from aeronautical projects and wind tunnel tests to microgravity flights and experiments. The Lewis complete digital archive, containing over 10,000 images taken on-site since 1995, is searchable through the NASA Image Exchange (NIX).

Stennis Space Center (SSC)

The Stennis Image Retrieval System contains still images and movies of general interest produced at Stennis Space Center. Selections include propulsion, Earth science, technology transfer, history, facilities, commercial remote sensing, education, resident agencies, and the visitor center.

7. Who do I contact about a problem?

The developers and maintainers of the NIX servers appreciate constructive comments regarding the services provided. If you have a problem using the service, or find any errors or missing information, please contact one of the following:

Server/Point of Contact/Email Address

NIX
NIX Development Team
sti+nix@larc.nasa.gov

Ames Research Center
Barney Corbin
bhcorbin@mail.arc.nasa.gov (active during NIX development)

Lisa Coyle
lcoyle@mail.arc.nasa.gov (current contact)

Dryden Flight Research Center
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Lewis Research Center
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Stennis Space Center
David Walters
david.walters@ssc.nasa.gov

8. What about copyright information?

For issues regarding copyright information and use of NASA images and logos, please see the following links: NIX copyright information and NASA Headquarters image copyright information.

9. How do I get a print of NASA images?

Due to current budget constraints, NASA does not make copies of images available to the general public. Copies may be made available to qualified mass media representatives and NASA research partners by contacting the Public Affairs Office from the responsible NASA Center.

However, several of the NIX servers have available a large, high-resolution version of the images for the purpose of high-quality printing. Many of these TIFF or JPEG files can produce 8×10 "300 DPI full-color images on color laser or ink jet printers.

NASA images may be purchased from several commercial sources. The NASA Headquarters Public Affairs Office maintains a list of sources of available NASA images.

Appendix C

Browse Categories From NIX

NASA Image eXchange (NIX) Home Page

Aeronautics

* Aircraft Types
  - Ames Research Aircraft
  - F-Series
  - Lifting Bodies
  - Rotorcraft
  - Thrust Vector Research Aircraft
  - Top 20 Dryden Aircraft
  - Unique Aircraft
  - X-Series
* Air Traffic Control
* Icing Research
* Propulsion
* Simulators

Space

* Human Exploration
  - Development of Space
  - Early Missions
  - Space Shuttle
  - Thermal Protection Systems
* Microgravity Research
* Mission to Planet Earth
* Spacecraft
  - Lifting Bodies
  - National Aero-Space Plane
  - Reusable Launch Vehicle
* Unmanned Exploration

Astrobiology

* Galaxies
* Kuiper Airborne Observatory
* Planets

Information Systems

* Computational Fluid Dynamics
* Robotics
* Virtual Reality / Telepresence

General

* Historical (Ames)
* Life Sciences

NASA Centers

* Aerial Photographs
* Wind Tunnels (Exterior)
* Wind Tunnels (Interior)

New Images

* Dryden Public Affairs Feature Photos of the Month

Appendix D

Text of Copyright Information from NIX

NASA Copyright Notification

GENERAL CONDITIONS

NASA materials may not be used to state or imply the endorsement by NASA or by any NASA employee of a commercial product, service or activity, or used in any other manner that might mislead.

NASA should be acknowledged as the source of its material.

It is unlawful to falsely claim copyright or other rights in NASA material.

NASA shall in no way be liable for any costs, expenses, claims, or demands arising out of use of NASA's cassettes and photographs by a recipient's distributees.

PHOTOGRAPHY

Photographs are not protected by copyright unless noted. If copyrighted, permission should be obtained prior to use. If not copyrighted, photographs may be reproduced and distributed without further permission from NASA. If a recognizable person appears in a photograph, use for commercial purposes may infringe a right of privacy or publicity and permission should be obtained from the recognizable person.

CONTACT

If further information or assistance is needed, you may contact:

NASA Headquarters
Office of Public Affairs
Media Services Division
News and Imaging Branch
Code PM
300 E St., SW
Washington, DC 20546
(202) 358-1900

Appendix E

Sample Questions From NIX Help Desk

Inquiries to help desk (STI Lead Center Information Desk) as of 12-1-97: ~300

Inquiries answered within 1 day: All

Most frequently asked questions:

1. Where do I find "a particular image?"
2. How do I use or download this image?
3. What is the copyright procedure for this image?
4. Where do I find a Hubble photo and when will NIX be linked to the Hubble Space Telescope image database?
5. Where do I find an image from the *Mars Pathfinder* mission?
6. When will specific images be added to NIX?
7. How do I obtain a print of the image?

Appendix F

Most Frequently Searched Terms and Frequency of Use for NIX

7843: earth
7026: space
6266: shuttle
4360: apollo
3797: moon
3514: mars
1797: launch
1341: mir
1290: hubble
1267: satellite
1027: saturn
983: station
943: pictures
854: pathfinder
807: images
796: photos
736: lunar
719: solar
692: from
639: rocket
626: astronaut
612: mercury
607: planets
596: aircraft
553: astronauts
523: system
508: walk
465: engine
455: nasa
448: eva
445: planet
437: mission
403: logo
397: x-15
382: jupiter
375: night
370: satellites
363: cockpit
352: center
352: gemini
350: suit
347: spacecraft
346: photo
340: sun
314: wind
308: challenger
306: tunnel
305: telescope
300: sr-71
295: control
259: stars
254: rover
250: module
240: vehicle
239: views
237: international
236: image
233: surface
226: flight
225: x-33
220: photographs
218: armstrong
213: venus
211: star
198: wing
191: voyager
190: kennedy
189: map
187: test
180: new
180: black
179: columbia
178: concept
166: europe
165: delta
162: crew
160: germany
156: liftoff
154: launches
153: sts
153: deep
152: hole
151: man
149: artist
147: atlantis
146: probe
145: galaxy
140: view
134: canada
131: picture
131: hurricane
131: america
126: aerial
126: flying
126: bay
122: italy
121: rockets
119: skylab
119: f-16
119: san
117: f-18
117: lift
117: lake
117: australia
116: neil
113: payload
112: supersonic
112: remote
111: global
110: galaxies
109: south
109: repair
109: sunrise
107: main
107: movie
106: micro
105: rms
105: fan
105: art
105: france
104: x-1
104: sensing
104: greece
104: pressure
102: blowing
102: kc-135
100: pad

Appendix G

NIX Technical Assistance to NASA Centers

1997 NIX Assistance

*Ames Research Center

*Dryden Flight Research Center

*Johnson Space Center

+Stennis Space Center

1997 NIX Technical Assistance

#Goddard Space Flight Center

#Lewis Research Center

1998 NIX Assistance

*Dryden Flight Research Center

+Kennedy Space Center

*Lewis Research Center

+Marshall Space Flight Center

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*Expansion grant
+Grant to provide initial link to NIX
#Technical support

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13. ABSTRACT ***(Maximum 200 words)***

This paper discusses the technical aspects of and the project background for the NASA Image eXchange (NIX). NIX, which provides a single entry point to search selected image databases at the NASA Centers, is a meta-search engine (i.e., a search engine that communicates with other search engines). It uses these distributed digital image databases to access photographs, animations, and their associated descriptive information (meta-data). NIX is available for use at the following URL: http://nix.nasa.gov./NIX, which was sponsored by NASA's Scientific and Technical Information (STI) Program, currently serves images from seven NASA Centers. Plans are under way to link image databases from three additional NASA Centers. Images and their associated meta-data, which are accessible by NIX, reside at the originating Centers, and NIX utilizes a virtual central site that communicates with each of these sites. Incorporated into the virtual central site are several protocols to support searches from a diverse collection of database engines. The searches are performed in parallel to ensure optimization of response times. To augment the search capability, browse functionality with pre-defined categories has been built into NIX, thereby ensuring dissemination of "best-of-breed" imagery. As a final recourse, NIX offers access to a help desk via an online form to help locate images and information either within the scope of NIX or from available external sources.

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